WINS NG 2.0 Current Status and Network Assembly

Santa Fe, NM

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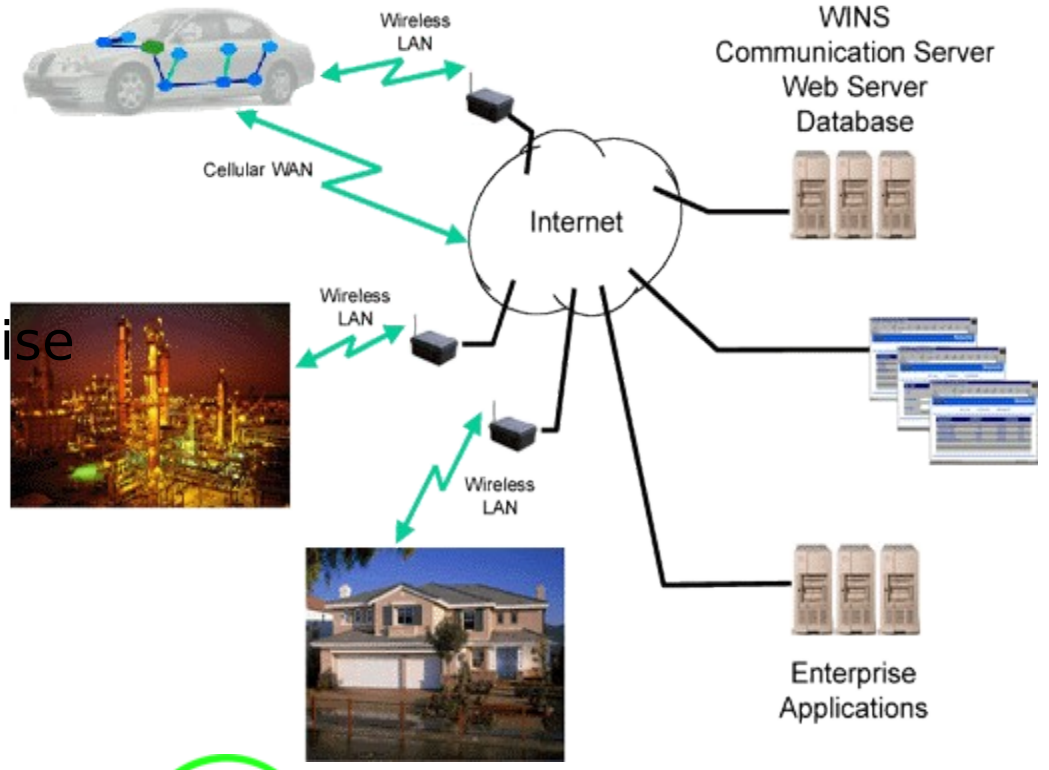
Sensoria Corporation

Internetworking the Physical World

Sensoria Corporation Introduction

- Sensoria Corporation is an innovator of networking embedded computing systems
- Products for:
  - Defense
  - Automotive
  - Industrial
  - Health Care Logistics
- Integrated Edge-to-Enterprise Platforms
  - SensIT Development
  - SHM Platform
  - PicoWINS Tags
  - Automotive Telematics Gateway



WINS Node Status

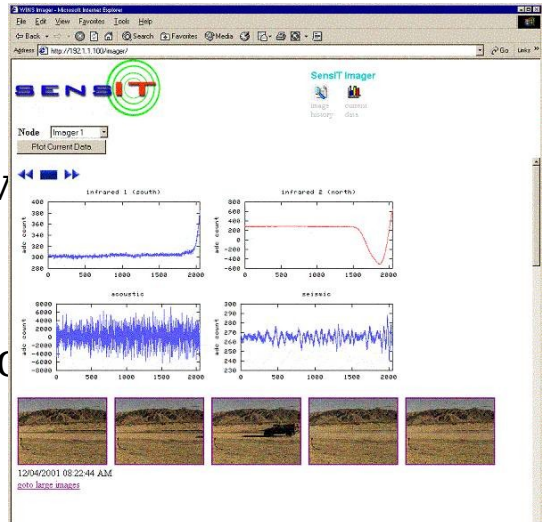
- Ninety WINS NG 2.0 development nodes have been delivered to the SensIT community prior to SITEX02.
  - Development platform including, high speed sampling, RF support, GPS, Linux 2.4 Kernel, …
  - Embedded sensing node with expanded capability to support development
- Additionally Two WINS Imager v.2 have been provided.
  - Authorized in October, delivered later that month
  - Provide WINS NG 2.0 development environment integrated with an imaging module, currently visible CCD
    - In process of evaluating use of uncooled thermal IR subsystems
- Latest v1.3 WINS NG 2.0 and Imager software updates provided December 2001.
  - Updates Linux Kernel to 2.4.16
  - Updates development tools, to track latest open source updates
    - Including 3.0.2 compiler
  - Refines RF and sensing APIs
    - Updates RF robustness
    - Updates capability of GPS synchronization with sampling

WINS NG 2.0 at SITEX02

- Seventy-five node WINS NG 2.0 nodes and two Imagers were deployed for SITEX02
  - Heavy utilization over 3 weeks provided user feedback on:
    - With complete software distributions were loaded at SITEX02, kernel panics were observed in the 2.4.8 kernel distributed with the first WINS NG 2.0 build
      - This was resolved with the open source community updates to the Linux 2.4.12 kernel operating on the SH4
      - Tested with a random input test (the crashme utility), operated on the nodes for extended periods without failures on the new Kernel provided at SITEX02
    - GPS module failures
      - ~10 nodes returned due to GPS module hardware failure
      - Currently testing operation and correcting available nodes
    - Requested updates to node synchronization
      - Coordinated with Pete Boettcher to allow PPS access on the SH4 to support NTP
    - Request for an http server to transfer images from the imager
      - Porting apache web server is in process
    - Feedback is appreciated, in order to duplicate and identify observed issues

Steel Knight Imager Deployment

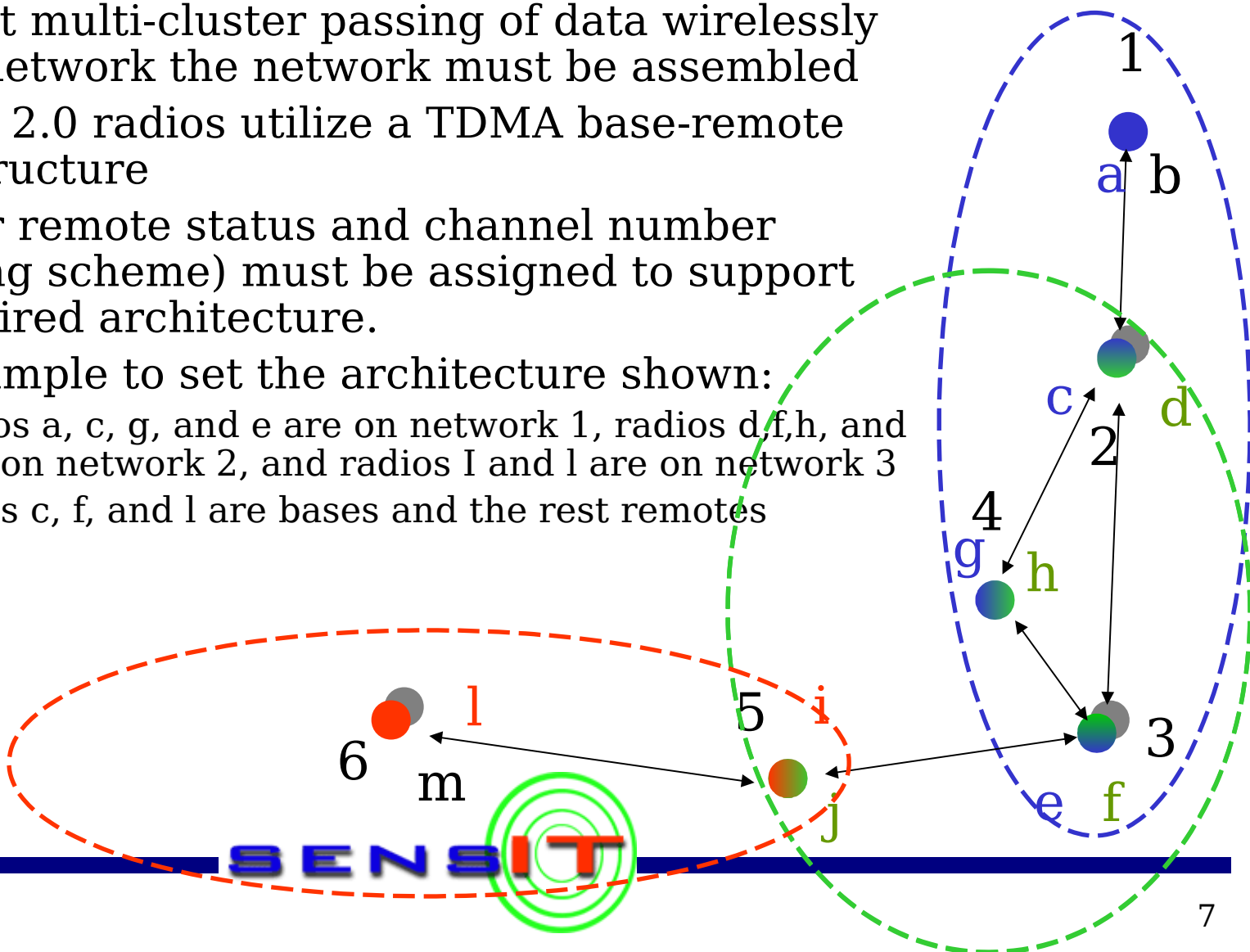
- To provide a SensIT demo at Steel Knight, Sensoria and BBN installed
  - 2 Imagers
  - a long range 802.11b link
  - a database server
  - a web based GUI
- WINS Imager v 2.0 operated continuously over a wee
  - Linux 2.4.12 kernel, with sampling API running continuously
  - Each Imager equipped with 2 PIR, seismic and acoustic
  - Imager's triggered locally with the PIR sensors
  - Only problem over two weeks when database serv was shut down accidentally (by W.J.K.)
- Provided imaging within seconds of vehicle passage
  - Sequences of pictures provided to capture, large c multiple targets



Steel Knight Sample Images

WINS NG 2.0 Network Assembly

- To support multi-cluster passing of data wirelessly over the network the network must be assembled
- WINS NG 2.0 radios utilize a TDMA base-remote cluster structure
  - Base or remote status and channel number (hopping scheme) must be assigned to support the desired architecture.
  - For example to set the architecture shown:
    - Radios a, c, g, and e are on network 1, radios d,f,h, and j are on network 2, and radios I and l are on network 3
    - Radios c, f, and l are bases and the rest remotes



Radio Configuration

- Function calls to configure each radio are available in the rfmodemd driver.
  - Ioctl() calls to configure the network, base/remote status, and Tx power
- Scripts can run on each node at start up to build there own deterministic networks.
    - Defined network for comparison with self assembled.
    - Reconfigurable for testing multiple scenarios.
- Suitable to a demo or experiment with a fixed node layout.
  - Autonomous network assembly a development option for each of the PIs, with Sensoria developing supporting technology to be delivered in the third year of the program
  - Additional need for self-assembled networks to place and forget

Autonomous Self-Assembly Considerations

- Each base supports up to 16 remotes, however 7 or less remotes per base are recommended.
  - RF channel TDMA sliced between base and remotes, limiting packet sizes as more remotes are added
- RF communication is environmentally dependent
  - Expected ground-to-ground distance is >30m at the MCAGCC desert environment.
    - Base to remote distance, per leg of the star or cluster.
  - Increases to >70m for nodes at a height of 1.5m.
- Base operation requires more power than remotes
  - To maintain synchronization without transmitting data bases use ~420mW, compared to ~90mW for remotes (at 100mW transmit power).
  - Additional cost to send data is ~20mJ/kbit at the base and ~50mJ/kbit at the remote.

Autonomous Self-Assembly Considerations

- Nodes decide base/remote and network state with local information
  - WINS NG 2.0 baseline is to use two default networks (known hopping patterns)
  - Each radio listens as a remote on one network
    - Becomes a base if does not hear another base after random interval
  - Updates to network structure (base and network assignment) based on:
    - Node locations within a cluster
    - Number of remotes per base
    - Remaining power
    - Link QoS, or signal strength
- Operation limited by robustness and adaptability
  - Respond to node destruction/ power failure
  - Incorporate new nodes with a minimum of communication
- Focus on a distributed decision, on each node to support multi-cluster multi-hop architecture

Conclusions

- 90 WINS NG 2.0 nodes supplied to SensIT
  - Operation demonstrated by multiple organizations both at SITEX02 and for this meeting
  - Continued upgrades and support of RF API, Sampling API, GPS, and Development Environment
- 2 Imagers v 2.0 supplied to SensIT
  - Demonstrated operation at the end of SITEX02, and at Steel Knight, also present here
- Next steps include:
  - Self assembly of the WINS NG 2.0 RF network
  - WINS NG 2.0 and Imager refinements